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The Wingship's Potential For Strategic Lift

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Abstract

A Wing-In-Ground-effect (or WIG) aircraft is a vehicle designed to fly just above the surface of the earth in an aerodynamic regime called "ground effect." Flying in ground effect allows greater fuel efficiency than realized by conventional aircraft. One large WIG design that combines the cargo capacity of a small ship with the speed of a large aircraft is currently being considered as a strategic lift vehicle. This "half-airplane/half-ship" is aptly called a "wingship." The main proponent of the wingship design is a company called Aerocon in Arlington, Virginia. In 1993, Aerocon successfully lobbied Congress to provide funding for a study to be completed by the Advanced Research Projects Agency (ARPA) on the potential of wingships as strategic mobility vehicles. This report looks at the preliminary findings of ARPA and the claims of Aerocon regarding the wingship's strategic mobility potential. These two different viewpoints provide most of the "pros" and "cons" of wingship development for the strategic mobility mission. Additionally, the report examines some other military, economic, diplomatic, and political factors that should be considered in a decision to pursue this new technology.

It concludes that, while wingships would make magnificent strategic lifters, they are not likely to replace current mobility assets in the near future. However, there are other missions that may be well suited for an interim prototype or technology developer. (This conclusion is in line with the preliminary recommendations of ARPA.) In any case, wingships are certainly a concept that "bears watching" and hold tremendous potential for future strategic mobility missions as well as other military and commercial applications.

About the Author

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INTRODUCTION

Since the fall of the former Soviet Union and the end of the Cold War, we've seen drastic cuts in defense spending. In anticipation of a "peace dividend", we've reduced our personnel levels, closed numerous bases at home and abroad, and trimmed away significant amounts of force structure. And yet, as recent events in Somalia, Haiti, North Korea, and Bosnia illustrate, the potential for United States military involvement anywhere around the globe remains high. With a much smaller military and greatly reduced overseas presence, it is imperative that we maintain an ability to rapidly project forces wherever and whenever needed. This ability to globally project force is often referred to as "strategic mobility"--and while the United States does this better than any other nation, we still don't have all the airlift and sealift assets or prepositioned personnel and equipment required to meet all our strategic mobility needs. Over the last few decades, this mobility "shortfall" was the focus of Department of Defense attention on improving our airlift and sealift forces through such programs as the C-17 and fast sealift ships. Improvements in both modes of strategic lift were deemed necessary--airlift delivers troops and equipment quickly but in limited amounts; and sealift delivers the bulk of equipment needed for the sustainment of forces but only after considerable "steaming" time. But what if we could solve our mobility shortfall with a vehicle that could carry bulk cargo like a ship with the speed of an aircraft? Such a vehicle may be possible. The Russians have been developing a "half-airplane/half-ship" for some time now with relatively good success. These vehicles are essentially airplanes that fly close to the surface of the ocean in a region of aerodynamics called "ground effect." For this

reason, these vehicles have come to be called "Wing-In-Ground-effect (WIG)" vehicles or "ekranoplanes" ("ekran" means "ground effect" in Russian).¹ In the United States, the concept of using WIG vehicles as large commercial or military transport vehicles is gaining interest. In the transportation role these vehicles are commonly referred to as "wingships." By flying in the ground effect, wingships are said to be able to achieve the fuel efficiency of a ship while flying at the speed of an airplane. This combination of efficiency and speed would seem to make wingships ideally suited for the strategic mobility mission. However, the practicality of wingships as strategic transporters has yet to be proven.

This paper will evaluate the potential of wingships as a future strategic mobility vehicle. To do this, I'll first discuss some background and history on wingship development. Next, I'll discuss some of the pros and cons of this emerging technology as uncovered by the most recent studies. I'll then analyze these pros and cons not only against the strategic mobility requirement but also in the context of our larger national interests. And finally, I'll draw some conclusions and make recommendations about the wingship's potential role as both a new transportation vehicle and an instrument of national power.

BACKGROUND

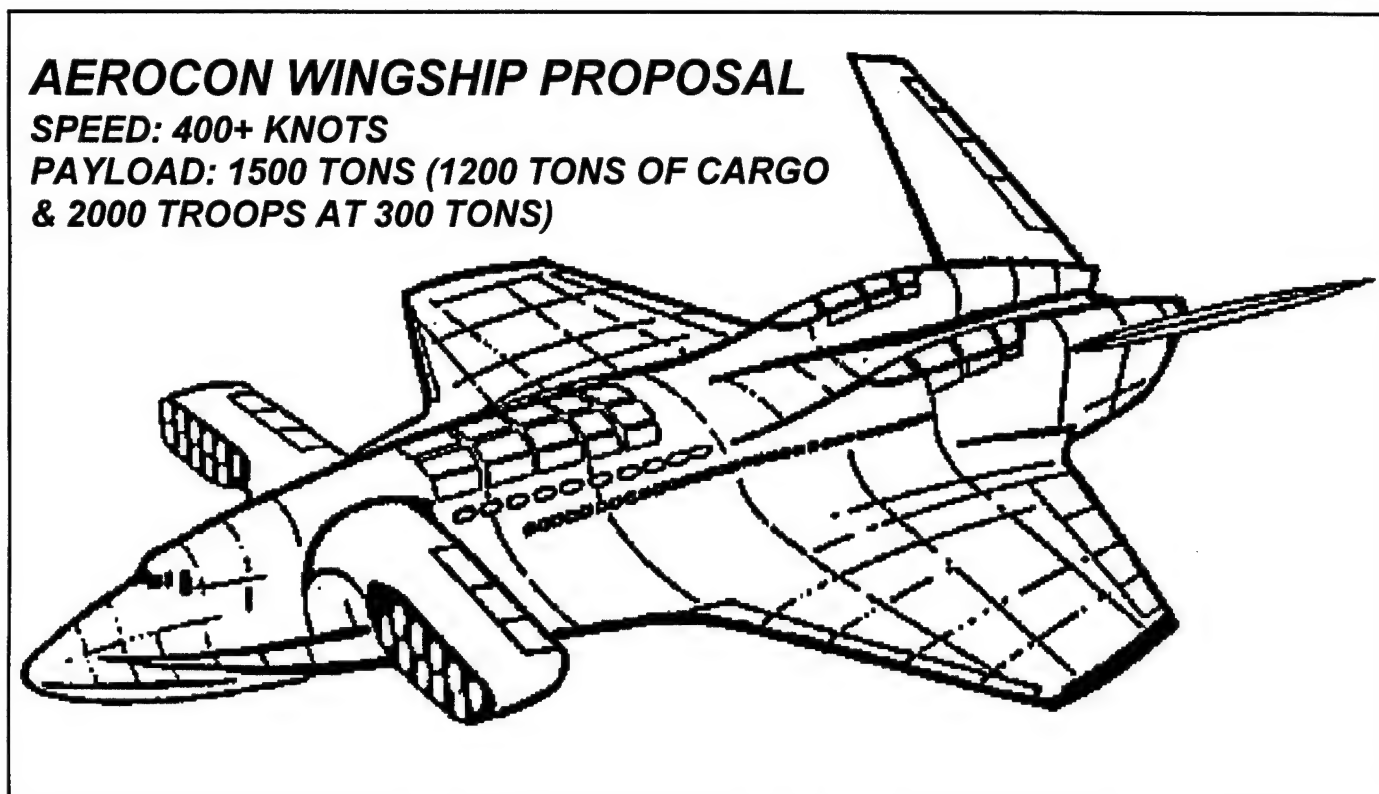
In 1967, a Defense Intelligence Agency (DIA) analyst was studying some satellite imagery of a strange looking craft skimming over the surface of the Caspian Sea. This craft resembled an airplane with short, stubby wings and a very large empennage (tail surface) and its dimensions confirmed it to be the largest flying vehicle of any type in the world. This strange machine was also different from other aircraft in that it was never observed flying over land or at those altitudes that were normally the domain of traditional airplanes. The craft was dubbed "The Caspian Sea Monster"--and a monster, it was! Total length was over 500 feet and the estimated gross weight was over 500 tons. The craft was a Soviet design and represented a technology where the Soviet's held a clear advantage over the West. Further analysis by DIA, revealed that the "sea skimming" characteristics of the Caspian Sea Monster allowed the craft to take advantage of an aerodynamic phenomena known as "ground-effect". Simply stated, ground effect is the way that the "ground" (or surface--in this case, the surface of the sea) improves the performance of a wing when the two come close to each other. All pilots are familiar with ground-effect when landing. As an airplane gets close to the surface it seems to want to "float" on the air just before touching down. Most pilots think of the phenomena as air being compressed between the wing and the ground and make adjustments to the controls of the airplane during landing to take advantage of this "cushion" of air for a smooth landing. Aerodynamicists have a more technically correct answer as to what "ground-effect" is and why wings perform better close to the ground--more on this later. Suffice it to say, that the Caspian Sea Monster was the culmination of years of

Soviet research in a new class of transporters known as Wing-In-Ground-effect or WIG vehicles.

Research in WIG vehicles has been around for some time. Several other countries have shown interest in pursuing this technology throughout the twentieth century.² But most of the vehicles developed were on a much smaller scale than those developed by the Soviets. The Caspian Sea Monster ushered in a new era in transportation. Though the Monster was originally envisioned as an anti-ship warfare vehicle, its increased flying efficiency might make it ideally suited as a strategic mobility platform. One of the first engineers to pursue this idea was Steven Hooker, an aeronautical engineer and DIA analyst who first observed the Caspian Sea Monster in 1967. He became so convinced of the mobility potential of this new type of vehicle that he left the Defense Intelligence Agency in 1983 to pursue the full scale development of a practical WIG transporter. In 1984, Mr. Hooker founded his own company, Aerocon, to develop a Wing-In-Ground-effect vehicle that had the cargo capacity and range of a small ship. Consequently he called his concept a "wingship" and this term is now commonly used to refer to a WIG vehicle designed for a transportation role. Hooker's vision for a wingship was a vehicle that was roughly ten times the size of the Soviet's Caspian Sea Monster. The Aerocon wingship would have a gross weight of over five thousand tons and a cargo capacity of around fifteen hundred tons. This wingship would cruise at over 400 knots and have transoceanic range. Compared to a Boeing 747, the wingship would be over 12 times the weight but carry 30 times the payload.³ What's more, because of the advantages of flying in ground-effect, the wingship would achieve operating efficiencies (cargo delivered per fuel consumed) as much as 44% better than today's cargo airplanes.⁴ A drawing of the

Aerocon wingship is at Figure 1.

Figure 1 The AEROCON WINGSHIP⁵



The impact such a vehicle might have on both the commercial transportation industry and military strategic mobility mission is obvious--a capability to deliver much larger volumes of cargo, in a shorter amount of time, all for a lower operating cost.

The wingship's potential as a solution to this nation's long-standing mobility shortfall was brought to the attention of Congress through the successful lobbying efforts of Aerocon. Subsequently, the FY93 Defense Appropriations Act provided five million dollars for the Advanced Research Projects Agency (ARPA) to determine if there was a military need for a wingship and, if so, how it might improve United States airlift and sealift capabilities.⁶ In

other words, could a wingship, like the one envisioned by Aerocon, provide a practical solution to this problem?

This is one of the questions the Advanced Research Projects Agency was tasked with answering through the FY93 appropriation. Overall Congressional direction asked for a technical evaluation; a model for experiment planning; a utility analysis; and whether or not there existed a validated DoD requirement for such a vehicle.⁷ To meet Congressional guidance, ARPA established four program objectives:⁸

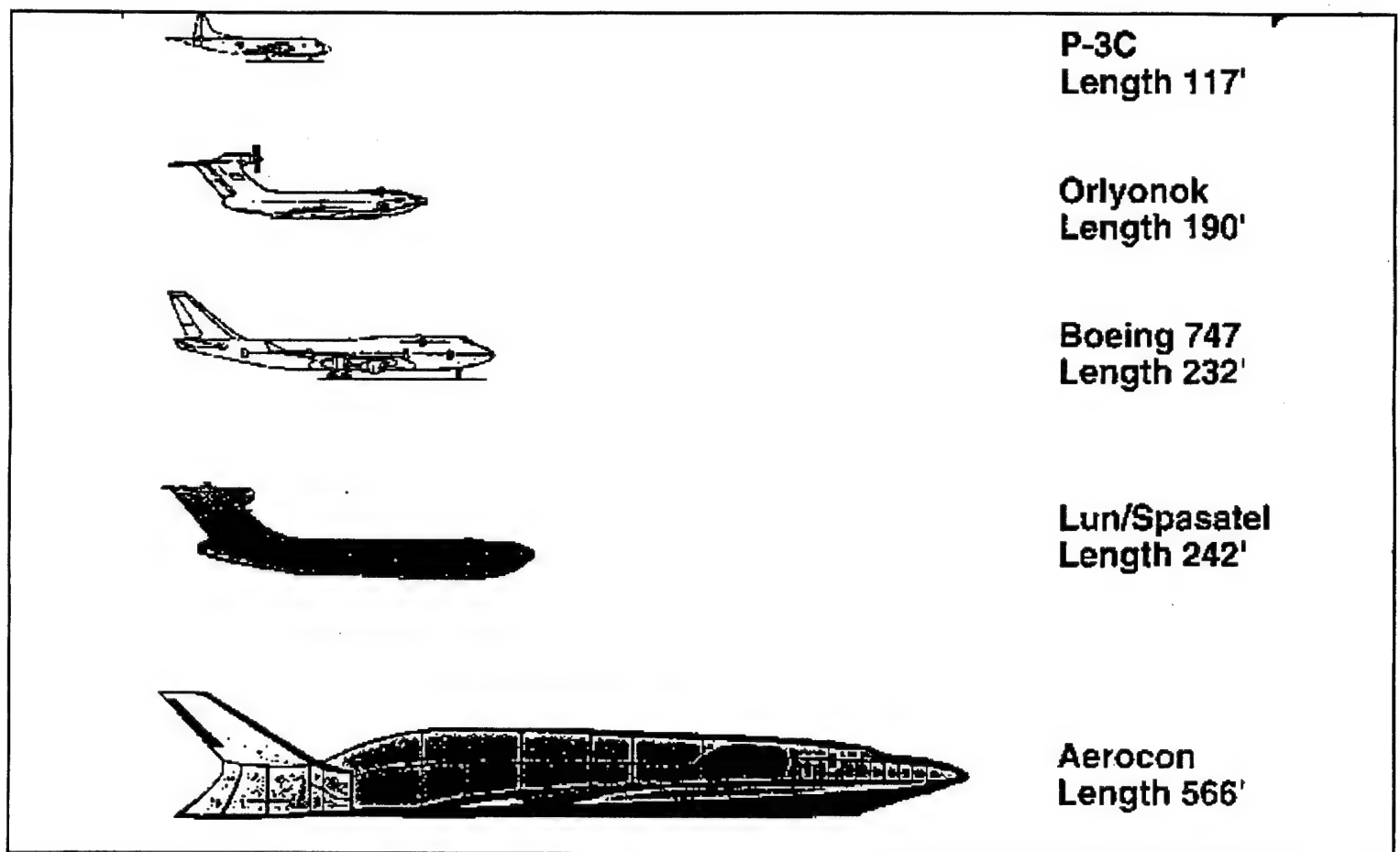
1. Understand "State of the Art" in wingship technology.
2. Assess Development/Operational Risks.
3. Understand the Potential DoD Role.
4. Provide a Recommendation to the Secretary of Defense.

To conduct the study, ARPA established two study teams. The Wingship Technical Evaluation Team (WTET) was tasked with the first two objectives--looking at the technical feasibility of wingships. The third objective was given to the Wingship Mission Analysis Team (WMAT) with the primary emphasis on looking at possibilities for strategic lift, but also they were asked to consider other military and/or civil missions that may be well suited to wingships.⁹ Of course the two teams would combine their studies in accomplishing the fourth objective--a final recommendation to the Secretary of Defense as to what extent wingship technology should be pursued in the United States.

One particularly important advantage that the ARPA teams had in conducting this study was access to Russian WIG technology. With production of such craft as the Caspian Sea Monster, Russia is the only country that has designed, built, and operated very large WIG

vehicles.¹⁰ They have over thirty years of research experience in this technology.¹¹ Though the Caspian Sea Monster crashed and sank some years ago, the Russians are currently building at least two different large scale WIG designs. The smaller version is called the Orlyonok and weighs about 140 metric tons. The larger version is called the Lun/Spasatel and is actually larger than a Boeing 747--weighing about 400 tons.¹² Figure 2 shows relative sizes of the Orlyonok and Lun compared to some United States aircraft.

Figure 2 RELATIVE SIZES¹³



Members of the ARPA team traveled to Russia in the spring and fall of 1993 to visit the TsAGI Central Aero-Hydrodynamics Institute in Moscow and the Central Hydrofoil Design Bureau in Nizhni Novgorod--where the large Russian WIG vehicles were produced.¹⁴ This exchange of information between Russians and Americans proved useful in accomplishing the ARPA objectives. (It may also provide a foundation on which to build future cooperative ventures--a benefit discussed later.) Preliminary findings of the ARPA study are just now coming available. They indicate both problems and possibilities with the wingship concept.

PROBLEMS AND POSSIBILITIES

Perhaps the biggest problem with the concept of a wingship for strategic lift on the magnitude of the one envisioned by Aerocon is that it has never been done before. As an Aerocon report stated, "like the Panama Canal or any number of large bridge or dam projects at the time they were first proposed the wingship is simply a major engineering enterprise that has never been before attempted."¹⁵ The largest WIG vehicle produced and flown by the Soviets was about 540 tons, whereas the Aerocon proposal is about ten times that at 5000 tons. This "order of magnitude" jump in size is a problem according to the ARPA study. A design in the 400-1000 ton range is seen as much more "technically feasible." (In other words no more than double the size of the largest currently operating WIG aircraft, the Lun/Spasatel). ARPA points out that the large size of the Aerocon wingship presents several other obstacles. Large size means large cost--perhaps more than \$60 billion to develop and billions more for production, operations, and support costs--although ARPA admits that costs are difficult to nail down. As one team member was quoted as saying, "It's like asking the Wright Brothers how much a 747 costs."¹⁶ Large size also means large power requirements to get the vehicle out of the water and into the ground effect. One of the earliest preliminary team findings stated that "the large power requirement associated with take-off is the single greatest impediment to overall efficiency and utility of this vehicle and must be overcome if wingships are to become efficient transports."¹⁷ The large power required for take-off as compared to that required for flight in ground-effect has been termed a "power mismatch" and the extra weight of carrying the engines associated with this mismatch may detract from the

envisioned efficiency of very large wingships.

Large wingships are also "large targets." Critics of the Aerocon design say that such a vehicle would present a lucrative target--an expensive strategic lifter carrying expensive combat firepower--highly vulnerable to enemy missile attacks. But certainly a wingship moving at over 400 knots would not be any more vulnerable to such a threat than current fast sealift ships cruising at 24 knots. Furthermore, sealift ships carry over three times the cargo of the proposed wingships making conventional ships even more lucrative targets.¹⁸ Aerocon has even argued that the wingship is an "ideal" size because it is "large enough to deliver combat units of serious proportions, but it is not so large that if destroyed or hindered, it would represent an unacceptable loss of combat potential or delay in marshalling assault resources."¹⁹ It has also been argued that the sea-skimming characteristics of wingships make them a more difficult target than a cargo plane flying at high altitude. The extreme of this argument suggests that the sea spray kicked up by a wingship may provide some type of "stealth" that would hinder radar detection.²⁰ True or not, the large size of a wingship would not seem to present anymore of a "target" problem than current airlift and sealift vehicles do. This is especially true in light of the diminished "blue water" naval threat from the once formidable Soviet/Russian navy.

In general, Steven Hooker and his team at Aerocon contend that the large size of his design does not necessarily mean "big" problems. In fact, Aerocon contends that a 5000 ton craft is necessary to realize the full potential of the wingship in the transoceanic strategic lift mission. Part of the argument is based on aerodynamics. A wing operating in ground effect is highly efficient because induced drag is reduced. Induced drag occurs on any wing in

flight when higher pressure air from the bottom of the wing spills over to lower pressure air on top of the wings at the wingtips. This spillover produces wingtip vortices which are like little tornados that trail off of each wingtip. These vortices (more commonly known as downwash or jetwash) consume power and retard the flight of the wing through a force called induced drag. When a wing gets close to the surface, the downwash has no place to go and induced drag becomes very small--that's when the wing is flying in ground-effect.²¹ How close the wing has to be to the surface before it is in ground-effect is a function of the size of the wing. Basically, the wider the wing (aerodynamicists call this the chord length), the higher above the surface ground-effect is realized. When traveling over the ocean, the distance between wing and surface continually varies because of waves. The large Aerocon design (with large, wide wings) would provide clearance of waves up to twenty feet high to allow for operation in rough seas.²² Smaller designs (with smaller wings) may be limited to operations in calm seas or else risk impacting a "rogue" wave at very high speed. (Proponents of smaller craft designs say the issue of "rogue" wave avoidance could possibly be addressed through the incorporation of different technologies--i.e. terrain-following radar, automated flight controls, etc.)

The issue of cost has also been addressed by Aerocon. They acknowledge that costs are hard to pin down but concede that full scale development and production would be an expensive proposition--ranging from \$6.5 to \$8.5 billion by their estimates.²³ However, they also claim that, over time, the program would save billions of dollars no longer necessary for other types of force projection (ships/aircraft); overseas ship deployment operations; maintaining overseas bases/prepositioning; and maintaining higher numbers of personnel to

support these operations.²⁴ Aerocon also notes that production of wingships could revitalize many different industries and help the overall economy.²⁵ (Of course, pretty much the same could be said of any project that the federal government was willing to invest billions of dollars in.) None-the-less, the idea does have some merit and will be addressed later in the analysis.

As to the "power mismatch" issue, Aerocon says the extra weight is analogous to the "extra weight" needed by conventional aircraft for take-off and landing such as landing gear, flaps, spoilers, brakes, etc.--things a wingship would not need.²⁶ They also state that "even if the worst projections of the mismatch were correct (i.e. thrust for takeoff being 4 to 5 times the cruise requirement), wingships would still carry between 1.5 and 2.5 times the payload per pound of (maximum) thrust and use less than half as much fuel per pound of delivered cargo as compared to conventional aircraft."²⁷

The large size of the Aerocon concept could also present many problems in the infrastructure and support facilities needed for an effective wingship transportation system. Would docking, and loading/unloading structures be compatible with those used by ships? How would a craft cruising at 400 knots be integrated with ships moving along at 15 knots? What kind of turbulence, sea spray, or other hazards may it present to smaller boats? Could a wingship use existing ports and/or inland waterways? What kinds of procedures would be necessary to integrate wingships with other transportation systems? Who would have authority for making sure these procedures are followed--maritime or aviation officials? All these questions would of course have to be answered before wingship transportation becomes reality. Aerocon, again, sees no problems in this area. From their perspective, the wingship

is primarily a ship. As such, they considered design dimensions, cargo loading/unloading equipment, etc. so that wingships would be able to do all the things a small cargo ship can do. (In some areas the wingship is even less restrictive. For instance, the wingship's shallow draft allow access to some shallow ports that ships cannot use.) Aerocon's own technical evaluation team did, in fact, have a civil engineer dedicated to researching "wingship docking and handling, wingship loading operations, sea lanes and near shore operational issues."²⁸ In general, there were very few issues relating to infrastructure that Aerocon has not addressed. On the contrary, they've raised some issues that others have not considered. For example, what would be the procedure for crossing a country's Air Defense Identification Zone (ADIZ)? They also pointed out that the wingship would not use tugboats to dock because current vehicle structure would not support them. (Because of this, the Aerocon design includes thrusters for in-port maneuvering.²⁹) This is not to say that all these support, procedure, and infrastructure issues would not present any obstacles to wingship design. Other interviews with ARPA team members underscored these issues being problems.³⁰ For the purposes of their study, however, ARPA assumed that the necessary infrastructure to support a wingship would be in place. In other words, ARPA used preferential assumptions in order to help keep cost estimates more conservative.³¹

In general, Aerocon believes that the biggest objection to the matter of size is more of a conceptual problem than one of technical infeasibility. Aerocon also argues that too much emphasis has been placed on extrapolation of data currently available and that only a full scale engineering developmental effort would provide an accurate analysis of the very large wingship design. In a recent interview, Mr. Hooker emphasized that at every juncture of their

studies they have challenged engineers from all disciplines to uncover technological "show-stoppers" in his wingship design. To date, he is not convinced that there are any.³²

Although Aerocon and ARPA seem to be in disagreement over many of the technical and mission-oriented aspects of the wingship concept, they both concur that this technology shows some promising "possibilities." For instance, the ARPA mission analysis team identified several missions areas that wingships may be well suited for and that current airlift and sealift assets do not have the capability to perform. These missions include things like:

1. Quick response precision strike platform (like a cruise missile carrier).
2. Special operations force insertion; deep submergence recovery operations.
3. Mine clearing and laying.
4. Deep sea submergence recovery.
5. Urgent resupply of ships afloat.
6. Disaster response (e.g. for oil spills).
7. High speed auto ferry (civilian use).³³

Preliminary results of the ARPA study indicate that a smaller design for a wingship (400 to 1000 tons) could perform the important missions above while providing a "technology developer" for larger wingship research.³⁴ A smaller wingship would also better address the concerns of ARPA cited in the preceding discussion (design, cost, and power). Aerocon also points out that there may be a variety of applications well suited to wingships of various sizes. In fact, Aerocon has been working with civilian companies to explore possible market areas. Nevertheless, they still believe the wingship's best potential could be realized by a vehicle in the 5000 ton range. The question remains, "Does the wingship have potential as a

strategic mobility vehicle?" I believe the answer to that question may lie beyond the scope of the many studies already done on both the wingship and strategic mobility. In essence, it requires a consideration of the question in the context of how it affects our overall national interests.

ANALYSIS³⁵

IS THE WINGSHIP AN ACHIEVABLE TECHNOLOGY?

There are certainly a great many potential problems that would have to be addressed before a 5000 ton wingship becomes a reality. The Aerocon approach is to work through each of these problems with a full scale engineering development to validate their original wingship concept. Preliminary results of the ARPA study lean towards a more incremental "go slow" approach--building upon currently operating technologies and designs.³⁶ Both sides, however, find common ground on one issue--cooperative development of this technology with the Russians. From the ARPA team's approach, the only "currently operating" designs are Russian. In fact, ARPA has already provided \$100,000 to the St. Petersburg State Marine Technical University for further technology research.³⁷ Aerocon has long been a proponent of joint Russian-American cooperation. In 1992, Aerocon signed an agreement with Russia's Central Hydrofoil Design Bureau to promote engineering development of a wingship.³⁸ Building upon the Russian experience while pooling U.S. and Russian technical resources would certainly improve the chances of perfecting wingship technologies. In a recent study, the National Academy of Engineering points out that global technology exchange "speeds the development and diffusion of new product and process technologies and new 'best practice' engineering...worldwide."³⁹ The combination of western "know how" in some advanced technologies and the Russian research experience is sure to produce results. In short, a cooperative effort with the Russians will definitely make wingship technology achievable. There are other benefits to be realized as well.

From a grand strategy viewpoint, the prospect of joint Russia-American cooperation in the development of this technology is very exciting and could have profound political and economic impacts. The international political benefits are obvious--an opportunity for two former Cold-War adversaries to work together on a project that could eventually benefit both economically. These opportunities are rare and perhaps have only been evidenced by efforts for joint cooperation in space--such as the recent rendezvous of the space shuttle with the MIR space station. We should not let such opportunities slip by. Politically such a venture could also bolster our efforts to assist the Russian transition to a market economy. Interest in WIG technology could encourage foreign investment and ultimately create a demand for Russian goods and services in this area. It may also form the basis for other cooperative ventures in a wide variety of fields. Anything that improves the state of the Russian economy is, in turn, likely to improve the chances for continued democratic reform. The importance of a healthy economy in ensuring the growth of new democracies is a theme emphasized in the current national security strategy of "engagement and enlargement."⁴⁰ International interest in wingships may also provide the Russians with some "political prestige" by drawing attention to a new technology that they essentially pioneered. Again, this represents a rare opportunity--currently there is little global demand for Russian technology in other areas. And finally, such a cooperative effort could provide some long-term economic benefit by creating a new market for a Russian product. Continued United States assistance in modern product development, production, and marketing would help achieve this benefit and be a much more desirable option than straight foreign aid--which is almost always a hotly contested issue with the Congress.

This cooperative effort may yield similar economic and political benefits on the domestic scene as well. In the first place, continued Congressional appropriations for technology development will be difficult to come by if the risk of successfully achieving that technology is high. Risk is minimized by increasing the resource pool and by capitalizing on the considerable Russian experience in this field. Politically, the wingship becomes easier "to sell." Risk minimization would also be an inducement for commercial industry involvement in wingship development. Various aircraft and/or shipbuilding companies may pursue these technologies if they perceive opportunities to either break into a vast, untapped Russian marketplace, or get in "on the ground floor" of a global market created by a new era in transportation. The economic implications from the creation of new jobs, revitalization of some industries, and increases in global trade are obvious. And of course, commercial investment in research and development would add to the resource pool and speed up advancement of the technology.

In sum, on this question of technology achievement, I think it can be done--even for the more daunting 5000 ton wingship concept envisioned by Aerocon. Granted, this conclusion is drawn more from a "grand strategy" perspective than a technical analysis. But as previously discussed, the technical experts seem split over many of the potential pitfalls. It is my opinion that the potential political and economic benefits could overcome any technical problems assuming a need for wingships could be validated.

IS THERE A NEED FOR WINGSHIPS?

As already mentioned, Congress essentially asked ARPA to answer this question in 1993 when it appropriated money for a wingship study. This was certainly not the first time that the government has expressed concerns over our strategic mobility capability. Prior to the Persian Gulf War, four separate Department of Defense studies concluded that we did not have enough sealift to meet mobility demands.⁴¹ Similarly, at least 17 major mobility studies conducted since 1974 have concluded that our "airlift requirements far exceeded capabilities."⁴² The Congressionally Mandated Mobility Study (CMMS), published in 1981, was the first comprehensive study of overall mobility requirements for the nation. The CMMS considered the ability of all mobility assets (airlift, sealift, and prepositioned equipment) to meet requirements and determined that the level of needed airlift alone ranged from 73 to 125 million ton miles per day (MTM/D). (A MTM/D is a notional measure of capability whereby one ton, airlifted one nautical mile, equals one ton-mile of capability.)⁴³ Strictly due to fiscal constraints, the study recommended an airlift goal of 66 MTM/D.⁴⁴ Since the CMMS was published, we've never even managed to achieve the fiscally-constrained goal. Current airlift capability is just under 50 MTM/D and projected to increase to just over 50 MTM/D out through the year 2020.⁴⁵ The actual experience of the recent Persian Gulf war suggests that other assumptions in the CMMS may have been overly optimistic. (Interestingly enough, a Persian Gulf conflict was one of the scenarios originally considered in the study.) A recently completed study done for the Air Force by the RAND Corporation found that airlift capacity had been significantly overestimated--"during the peak month of airlift activity in support of the Gulf War, the largest airlift of all time, the United

States' airlift produced only 19 million ton-miles per day."⁴⁶ Similarly, a study at the Naval Postgraduate School concluded that "Operation Desert Shield highlighted tremendous problems with our nation's ability to effectively move our army and equipment to distant theaters."⁴⁷ Since the end of Desert Storm, several new studies have been done to reevaluate the nation's strategic mobility needs. For instance, the DoD's Mobility Requirements Study (MRS) completed in 1992 and MRS Bottom-Up Review Update (the MRS BURU--to be completed in early 1995) will establish new mobility requirements. Specific results of the studies are classified, however, they still indicate that the United States has a overall strategic mobility shortfall.⁴⁸ Does that mean we need wingships for strategic mobility?--not exactly!

There is no doubt that a machine that could transport ten times the payload of our biggest current airlifter at the same speed would improve our strategic mobility. A recent deployability analysis conducted by the Military Traffic Management Command (MTMC) looked at closure times for a variety of forces deploying to several different theaters using both wingships and projected airlift/sealift assets in the year 2005. They considered two different sizes of wingships--one that could carry a 1725 ton payload (an Aerocon design) and a smaller version designed by Northrop with a payload of 900 tons. The recommendation from their analysis was that "based on the enormous potential value the wingship can add to the capability of the Defense Transportation System (DTS)...that further, more detailed analysis be conducted on this very capable transport design."⁴⁹ A similar study conducted at the Naval Postgraduate School using a parametric analysis model concluded that force closure could be dramatically improved with the use of wingships.⁵⁰ What is rather obvious from the studies, and in fact doesn't require a study at all, is that the more wingships you use in the

analysis and the bigger their payload capacity (e.g. Aerocon versus Northrop design) the more quickly closure is obtained. But closer examination of the data from the MTMC study shows that a force of 23 Aerocon 1725-ton payload wingships would reach closure for a Corps-size force to Southwest Asia just one day earlier than projected (2005) airlift and sealift forces. On the other hand, a force of just 12 Aerocon wingships could deliver an early entry sized force to Southwest Asia in just two days compared to six for projected conventional lift assets.⁵¹ Is the difference in closure times for either of these two scenarios significant? The answer to that question is the key to determining whether or not we need wingships for strategic mobility.

Consider, first of all, what will change between now and the time we could realistically expect wingships to be operationally deployed. To be consistent with the MTMC analysis let's assume that time to be ten years from now--2005. (The average time for a major weapons system to reach initial operational capability from an acquisition "milestone 1" decision actually is closer to 13.5 years--so this is an optimistic assumption.)⁵² How much different will the battlefield be by then? Mr. Andrew Marshall, who heads the DoD Office of Net Assessment believes we are in a "military revolution" that will completely change the way we fight future wars.⁵³ He envisions an era of dominant battlefield awareness courtesy of greatly enhanced C4I and spaceborne sensors, and increased use of highly lethal precision munitions. Efforts are also currently underway at the United States Central Command (USCENTCOM) specifically aimed at reducing the weight and cargo volume requirements of our deployment forces.⁵⁴ And at the United States Transportation Command (USTRANSCOM) and the Defense Logistics Agency (DLA), Total Asset Visibility (TAV)

and In-Transit Visibility (ITV) are efforts to improve the efficiency of all our overall logistics systems that will alleviate demand on transportation assets.⁵⁵ What's more, the overall size of our military forces is being reduced. All these trends and initiatives should reduce our mobility requirement. The point being that when and if wingships are deployed our strategic mobility needs may be very different from those existing today. As envisioned by Mr. Marshall, future forces "would require less logistical support {which equates to} fewer transport ships and planes."⁵⁶ Therefore, our current and projected strategic lift needs may be more than sufficient especially in those scenarios where wingships provide only marginally better closure times. But just because wingships may not be *needed for strategic mobility* does not mean that a need does not exist.

I've already listed some of the missions that the ARPA team thinks could be done with wingships. Many of these missions cannot be accomplished with either current or project capabilities. In other words, a *need* exists. One mission in particular, that of disaster response, seems to be growing in importance--especially if you expand that mission area to include all other kinds of "peace operations" or "operations other than war." This would include things like the introduction of peacekeeping forces or humanitarian relief missions which have witnessed almost exponential growth in the last couple of years. In fact, peace operations have increased over 500 percent in the last five years.⁵⁷ In this role, wingships could become a welcome sign of American goodwill by delivering urgently needed food, equipment, shelter, and medical supplies worldwide. Aerocon has already proposed a concept of a wingship deliverable 600+ bed hospital complex that would be well suited for these types of operations.⁵⁸

In sum, when it comes to the question of need, there are certainly missions that the wingship could perform for which no other capability exists. That need would have to be more clearly defined in a mission needs statement as the first step in pursuing wingship development. However, when it comes to strategic mobility, there is not a clear requirement. Wingships would no doubt help to close our current strategic mobility shortfall. But the real issue is whether that shortfall will exist at all when wingships are fielded and, if so, are they the most cost-effective way to satisfy the requirement.

ARE WINGSHIPS COST EFFECTIVE?

As already mentioned, wingship program costs are very difficult to measure. ARPA estimates more than \$60 billion dollars just for development. Aerocon estimates are considerably less--but still represent a very expensive program with \$10 billion dollars for development and initial production costs of around \$400 million dollars per vehicle.⁵⁹ These figures were based on an initial production run of 10 to 15 wingships. For the sake of an optimistic argument, I'll use 13 wingships and the Aerocon figures to arrive at a program cost of \$15.2 billion. (Thirteen wingships were selected because it is the same as one of the scenarios modeled in the MTMC deployability analysis that realized a considerable closure advantage over traditional airlift/sealift modes.)⁶⁰ The table below shows what could be purchased if \$15.2 billion were used to buy traditional airlift and sealift assets.

\$15.2 BILLION BUYS...	13 AEROCON WINGSHIPS	63 C-17 CARGO AIRCRAFT ⁶¹	69 FAST SEALIFT SHIPS ⁶²	102 C-5 CARGO AIRCRAFT ⁶³
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Table 1 "Opportunity Cost" of Buying Wingships

In general, the amount of "traditional strategic lift" that could be purchase with the dollars needed for small wingships fleet is considerable. According to RAND, \$15 billion dollars represents the entire 25 year life cycle cost of buying forty-two 747-400F cargo aircraft.⁶⁴ The same amount of money is about three times as much as Congress appropriated for the upgrading and procurement of sealift vessels from 1990 through the end of the decade.⁶⁵ Of course if the higher estimates of ARPA are used even more capability could be purchased with traditional airlift and sealift forces.

Besides comparisons with traditional lift modes, wingships may also be competing with

other innovative approaches to improving strategic mobility. For instance, studies are currently underway to look at using oil-drilling platforms as "floating islands" that would enhance our prepositioned equipment and force projection capability. The platforms could be linked together to receive cargo aircraft as large as C-130's.⁶⁶ Airships and new "super-jumbo" cargo aircraft are also concepts that are being looked at and may compete with wingships in future mobility roles.^{67 68} One advantage that the wingship has here is the considerable amount of study and research (especially by the Russians) that has already been conducted in the concept. That research has uncovered some benefits of this new technology that, while harder to quantify, bear mentioning in a discussion of cost-effectiveness.

Aerocon has always promoted the wingship as a more efficient means of transportation. According to their calculations, the wingship could deliver one pound of cargo for each pound of fuel consumed--a five fold savings in fuel consumption when compared to traditional cargo aircraft like the C-5.⁶⁹ If wingships became a common mode of transportation in the commercial world as well, fuel savings alone may amortize the high initial developmental and procurement costs over time. Aerocon also cites savings by reducing the need for stationing American troops overseas, because of the ability to rapidly project those forces worldwide with wingships. However, from a grand strategy viewpoint, I don't think a reduction much below current levels will happen. Politically, United States presence overseas is still an essential element of regional stability in areas like central/southern Europe and Korea. Stationing forces abroad demonstrates a commitment to honor existing treaties and alliances to both our allies and potential aggressors. A minimum presence will always be required, and I think we are just about there now.

Domestically, ambitious wingship development and production would certainly benefit the economy--some of these benefits have already been discussed. More importantly, the wingship may be exactly the "shot in the arm" needed to help the United States' ailing shipbuilding industry. Shipbuilding has been an industry in steady decline since the days of the clipper ship (except for some anomalies caused by the first and second world wars).⁷⁰ Wingship technology may be just the thing that would allow U.S. firms to regain a leadership position in maritime transportation. It may help preserve this very important part of our industrial base. Also, because of the "hybrid" nature of the technology many of these benefits would likely spill over into the aviation industry. It may, in fact, lead to the creation of an entirely new industry group.

Politically, wingship development is right in line with the current emphasis on "dual-use" technologies and technology development. The Office of Science and Technology is always looking for promising technologies that could benefit both the military and commercial sectors. The wingship is a concept that should interest any firm engaged in global trade and as international trade restrictions continue to fall (as evidenced by NAFTA, GATT, etc.) this interest should continue to expand.

Are wingships cost-effective? That depends on your perspective, how you measure costs and benefits, and what you compare them to. There are many ways to frame the argument and different conclusions that can be drawn--mine follow.

CONCLUSION

The wingship is certainly an exciting new technology. Many familiar with the concept make comments like "bears watching", "enormous potential", and "an unexplored frontier in mobility." (In fact, a "WIG plane for massive lift" was one of ten revolutionary ideas recently selected for further study from over 1000 proposals under the Air Forces' new long-range planning process--"Air Force 2025."⁷¹) Now we are beginning to explore the "frontier" and some of the results are not as promising as, perhaps, originally hoped for--but no frontier is explored without setbacks. In this age of budget cut-backs, it is imperative to spend wisely. In the military, that means we should get the most capability we can for every dollar spent--commonly referred to as "the most bang for the buck." But as the entire federal budget shrinks, we also need to consider what benefits might be realized outside of the military environment, especially for those programs that are very expensive. In other words, we need to think about what the political, economic, and sociological impacts of such a program might be. The program, first and foremost, must satisfy the military requirement but the effects in these other areas should be congruent with our national interests. These secondary effects are often hard to quantify and, more often than not, require a longer range strategic perspective to fully realize their benefits. This is the case for the wingship.

There is no doubt that the wingship envisioned by Aerocon would be a magnificent strategic transporter. But at almost half a billion dollars apiece it's unlikely they would be funded in the current fiscal climate. It's simply a matter of "what we would like" compared to "what we can afford" to get the job done. On the basis of strategic mobility alone, I don't

believe a case could be made that would support buying wingships over other kinds of strategic lift. Furthermore, I think our lift requirements will see dramatic revisions in the coming decade due to changes in the nature of the battlefield and reductions in the size of our forces and the equipment they need to accomplish the mission. The introduction of other variables, like new alternatives to prepositioning (e.g. floating base platforms) will further complicate the determination of need. This, in turn, would make large scale development funding even less likely.

For all these reasons, I think that the ARPA recommendation for continued research and development of the wingship concept is appropriate. A smaller design would serve as a prototype or technology developer and, at the same time, be compatible with accomplishing some of this missions for which we currently don't have any capability. This approach would also lend itself to continued United States and Russian cooperation which has the potential for significant political and economic benefits to both countries. While this incremental approach wouldn't produce a 5000-ton wingship, it would keep the door open on this potential "dual-use" technology and may be a stepping stone to achieving the Aerocon vision sometime later.

Finally, I think it's important that we keep the Aerocon wingship vision alive. If we are, in fact, standing on a new threshold of transportation it would be a terrible shame to sweep it aside. Technologically, a 5000-ton wingship is a daunting challenge. But our country has accomplished some of the most amazing engineering feats the world has ever seen.

Challenge is what drove us to build a Panama canal and, later, a Saturn V rocket that took us to the moon. Surely, the recent technology explosion in computers, design, and engineering would allow us to build a very large wingship without too much difficulty. I think all it

would really take is the "national will" to want to do it. A recent article on the Boeing 747, one of the most commercially successful airplanes in the world , starts out by saying "they said it was too big, it couldn't be built, (and) it would never fly." ⁷² Some people at Boeing were visionary enough not to believe it. It would be a shame if wingships turn out to be the "747's" of the future, and we pass that opportunity by.

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27. "General and Specific Comments on the WTET Committee Draft Report (Draft)," p.3.
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29. Interview with Mr. Steven Hooker and Mr. Robert Vaughn, 9 Feb 95.
30. Interview with Col Mike Francis, Advanced Research Projects Agency (ARPA), Nov 23, 1994. and Mr. C.F. Synder, Naval Surface Warfare Center (NSWC)-Carderock, Jan 13, 1995.
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35. My original intent for this analysis was to compare the wingship to current strategic mobility resources (airlift, sealift, and prepositioned material) and see if it made sense to use it as a strategic lifter. I envisioned answering three questions to make that determination. First, is the wingship an achievable technology? Next, is there a need for such a vehicle? And finally, would such a vehicle be the most cost effective way to satisfy the need? A negative answer to any of these questions would mean the wingship just didn't "make sense." During the course of my research I discovered that this wasn't the correct approach. Before the reader jumps to the conclusion of many who have undertaken such studies--mainly that I couldn't find enough material and data to support my research--let me assure you that was not the case! In fact, the opposite situation occurred. I uncovered an almost overwhelming plethora of facts, figures, data, reports, briefings, studies, and even videotapes on the subjects of wingships and strategic mobility. (For that, I would like to take this opportunity to thank all who contributed--most notably Col. Mike Francis at ARPA; Mr. Paul Scesney at Decision Science Applications, Inc.; Mr. C. F. Snyder at the Naval Surface Warfare Center-Carderock Division (NSWC-CD); Mr. Steven Hooker and Mr. Robert Vaughn at Aerocon, Inc.; and Mr. Keith Seaman and Col. Brian Binn at the United States Transportation Command (USTRANSCOM).) The approach to the analysis was not wrong for lack of information or because the questions I originally posed were not pertinent. In fact, it's exactly those questions that many experts in their fields (some of whom are mentioned above) have been attempting to answer for some time now. My approach was wrong because it did not consider what sort of new contribution I could make to this analysis as a student at the Industrial College of the Armed Forces (ICAF). Like the other senior service schools, ICAF is supposed to transition its students to strategic level thought about a wide variety of issues affecting our

national security. Unique to the ICAF curriculum, however, is our study of "the ability of the nation to allocate its resources in support of its national security strategy." It is from this "ICAF-unique" strategic focus that I think I can best add some value to this analysis. (The use of wingships for strategic mobility would make an ideal ICAF case study because it touches on virtually all aspects of our curriculum.) Therefore, this analysis will still attempt to answer the three questions posed above--realizing that there are very few questions that can be answered with a simple "yes" or "no". However, it will also consider a number of issues that affect our national interests or impact our national security strategy. In other words, I'll be considering each of these questions in the context of what is commonly referred to as the "grand strategy" framework studied at ICAF. The grand strategy framework simply recognizes that all government actions (like buying a wingship) are affected by and affect the world around us. These effects can be economic, military, political, and sociological and can occur in the national or international environment. Successful government decisions require consideration of these effects in all areas. Bad decisions often result when the focus of these effects is too narrow.

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44. Strategic Mobility: Getting There is the Big Problem, p.11.
45. 1995 Air Mobility Master Plan, p.1-24.
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